DOI: 10.22616/j.balticsurveying.2018.014

POSSIBILITIES OF USE OF REMOTE SENSING TECHNOLOGY IN SURVEY PROCESS IN THE TERRITORY OF PILS ISLAND IN JELGAVA

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Abstract
In the study, creation of 3D surface relief model in Jelgava, for southern part of the Castle Island is depicted. Information about remote sensing, its historical development, as well as directions of remote sensing, development of photogrammetry and laser scanning is summarized and analysed. Principles of work and methods of photogrammetry and laser scanning. Information about creation of surface relief model from planning of unmanned aircraft, data capture and alignment to the end product – surface relief model. Application of evaluation of data obtained. The purpose of the study – to create 3D surface relief model in Jelgava, for the southern part of the Castle Island.
Tasks of the study – to consider development and improvement of photogrammetry and its processes, as well as development of laser scanning and principles of its work; to research, analyse and describe technological processes of laser scanning; to create 3D surface relief model in Jelgava, for the southern part of the Castle Island; to perform comparison of surface models obtained and describe application of laser scanning.
Preparation of surface relief model is time-consuming process, which includes flight planning and preparation of end-product. End-products obtained in data processing of laser scanning have very broad usage in many sectors related to geodesy and construction.
Key words: remote sensing, photogrammetry, laser scanning, relief, 3D model.

Introduction

Already long time ago, mankind interested, what is shape of Earth. We can look to it best from satellite images. These images give visual outlook to shape of Earth, relief, situation of various objects. From satellite images we can forecast, as well as model diverse situations, which could emerge on region of Earth, or endanger existence of individual regions or towns, as well as natural disasters, volcano eruptions, tornado.
Satellite images are as the big brother for smaller photographs, which can be taken by diverse methods of photogrammetry. New technologies enter the sector of land surveying. By them work can be done safer, faster and more interesting. One of the newest technology is laser scanning, result of which is point cloud, from which diverse 3D models can be created.
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Methodology of research and materials

For the preparation of the study, diverse databases of scientific papers, materials from Internet resources, normative acts included, publications and books were considered. In order to examine, study and analyse the available literature, monographical (descriptive) research method was used. In order to research and analyse remote sensing methods and usage, abstractly logical method and technique of the method – analyse was used.
Photogrammetry and remote sensing is art, science and technology for obtaining of reliable information about the Earth, surrounding environment and other physical objects and processes, by

data capturing by non-contact imaging and other sensor systems and measuring, analyse and depiction of them (Vanags, 2003).
Photogrammetry can be regarded as one of remote sensing methods, the main task of which is geometrical reconstruction of objects. It is possible to make photogrammetrical measurements in images. They can be done in one image, in pair of images or in several images or in block of images. Images can be photographic or digital. Measurements are usually performed by special instruments or on screen of computer. There was stereoscopical vision and measuring principle used on these measurements. They can be performed also automatically, by use of special correlation algorithms. Depending on the fact, how the photogrammetrical surveying and geometrical reconstruction of objects is performed, photogrammetry can be classified into analogic, analytical and digital photogrammetry (Casagli et al, 2016).
Depending on distance to the object, of which photo shall be taken, and location of photocamera aerial photogrammetry and terrestrial photogrammetry are distinguished.
Aerial camera with unmanned aircraft is lifted in some specific height that depends on location of the object, features of the relief. Thus possibility to fix situation from top is created. Main sector of usage of aerial photogrammetry is production of topographical maps and plans, as well as production of orthophoto maps (Mulder et al., 2011). Data obtained for purposes of topographical maps and plans in the photogrammetrical way is called digital terrain model, which can be the base of geographical informations systems. The necessary accuracy can be obtained, if corresponding scale of the image is selected (Zarrabeitia, 2013).
In the terrestrial photogrammetry, distances to the object, photo of which shall be taken, are relatively small. In this case, camera is installed on tripod and situation can be fixed in arc of 360 degree. It is used in architecture, in surveying of buildings and other engineering objects, in monitoring of construction etc. (Vanags, 2003).
Systematical observation of large territories and even of whole surface of Earth became possible only due to artifical satellites. One of the first examples, but still globally important civil remote sensing tools are USA multispectral satellite series „Landsat" with spatial resolution within 15 – 30 m, out of which „Landsat-1" was launched 1972, but „Landsat-8" – 2013. Later civil satellites with considerably greater spatial resolution were launched, as French series „Spot" (the newest satellites „Spot-6" and „Spot-7" have 1.5 m or 6 m resolution depending on work mode), „WorldView-3" (multispectral images with 1.24 m resolution), „RapidEye" (5 m resolution) etc. (Talizpete, 2017).
French colonel A.Losedo is considered as founder of photogrammetry. 1859 he gave lecture to the commission of Academy of Science of Paris on the method, how from a pair of images by a spatial crossing of rays it is possible to determine coordinates of the object (Lillesand, 2014).
In Latvia, geodesist Alvils Buholcs has given large contribution. He developed method of determination of deformation in stereophotogrammetry, has invented aerial photograph transformation apparatus in aerial photogrammetry and has improved radialtriangulation method (Kletnieks et al., 2000).
Electronic data processing created large changes in photogrammetry. It allowed to replace many optically mechanical components in stereoinstruments and to develop analytical photogrammetry, as well as aerial triangulation, which considerably allowed to reduce number of support points, which are to survey geodetically (Vanags, 2003).
The first technology of 3D scanning was created in sixties of 20th century. Original scanners used lights, cameras and projectors, in order to execute this task. Due to limitations of the equipment often much of time and efforts was necessary for exact scanning of objects. After 1985 they were replaced with scanners, which could use white light, lasers and shadows in order to depict certain surface (Lillesand, 2014).
3D laser scanner works, firstly by projecting laser light to object or surface, then the reflected light is determined. Based on that, where lighting is one-to-one, scanner calculates their positions and creates data points. These points help to computer renew visually (Nerlich, 2012).
Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on-site observation. In current usage, remote sensing refers to use of aircraft-based sensor technologies in order to determine and classify objects on surface of Earth, in atmosphere and in oceans, by use from satellite, aircraft emitted, and then from

object reflected and accrued electromagnetic radiation or also dissipated solar light (Lillesand et al., 2014).
The contemporary remote sensing of Earth surface is carried out mainly in diverse ranges of electromagnetic radiation – in visible light, infrared radiation, radio waves. In specific researches, gamma ray range is also used, however we shall not consider them more. The used instruments usually are installed on artifical satellites, aeroplanes or unmanned aircrafts. Remote sensing as branch of science researches data processing methods, by which it is possible from image obtained by the instrument to get valid information (Hadj Kouider, 2017).
Data processing methods of the remote sensing are gradually developed for several decades, still practical usage of them causes difficulties. In uncountable potential application sphere, remote sensing data are not used in practice due to results that can be difficultly interpreted. For obtaining of valid, practically usable results it is optimally, if in the research remote sensing specialists, which have a good knowledge of all nuances of image processing methods, and specialists of science sectors, which know end usage sectors in details, are working (Talizpete, 2017).
In order to reconstruct position and shape of objects from images, you have to know geometrical laws, which makes a base for formation of photographical image.
Photographical image emerges, when in plane of image light rays coming through camera objective are projecting, where light-sensitive film emulsion detects them. After developing and copying, image is obtained, where measurements can be done. Similarly, digital image is obtained in digital sensor, which is saved and which can be displayed in monitor of the computer. As measurements are made in photogrammetry, the obtained picture and also camera shall be described geometrically. In cameras, images are obtained, which with sufficient accuracy can be regarded as central projection of spatial objects depicted there. Map, however, is ortogonal projection of terrain on projection plane in certain scale. Every object is projected in straight angle according to this plane. All rays of projection are parallel. Such projection could be obtained theoretically, if distance to camera is infinity. Main task of photogrammetry is to convert the central projection into ortogonal projection (Vanags, 2003).
Aerial laser scanning allows to obtain information also about soil under plants, which is not provided by aerial photography, because part laser rays among plants comes to the surface of Earth. Accuracy is provided in decimeters (Vanneschi et al., 2017).
Accuracy and quality of results of laser scanning depends on many circumstances, for example, on device and method chosen, on basic network and number, configuration and accuracy of control points, from weather etc. Knowledge and experience of performer of the work are the most essential factors. We shall count on the following – the more accurate are results, we wish to obtain, the more expensive it will cost. There is often desire to receive data with 1 mm accuracy in the practice, although in reality 1 cm accuracy would be completely sufficient (Smilga & Partna, 2016).
As it was afore-mentioned, the purpose of the research was creation of 3D surface relief model in Jelgava, for the southern part oft he Castle Island.
In order to create 3D surface relief model, not only rather broad technical equipment, but also skills and knowledge in the sector of data capture, processing and preparation is necessary.
In order to be capable to execute tasks of remote sensing, rather large technical equipment is necessary. Firstly, unmanned aircraft with camera is necessary, by help of which photoimages are taken and by processing of them photo visualization is created. In the same way, unmanned aircraft with laser scanner is necessary, in order to perform scanning and to prepare surface relief model from data obtained. Certainly, software will be necessary in the area of data alignement and for further work with aligned data. It is necessary to perform control measurements, this can be done by GPS.
In order to give broader insight into application of laser scanning data and possibilities in general, two surface relief models were prepared. As well as they were compared mutually. Data for preparation of the first relief model were obtained by organization of laser scanning, i.e., laser scanning was performed on 9 March 2018 (see Fig.1).

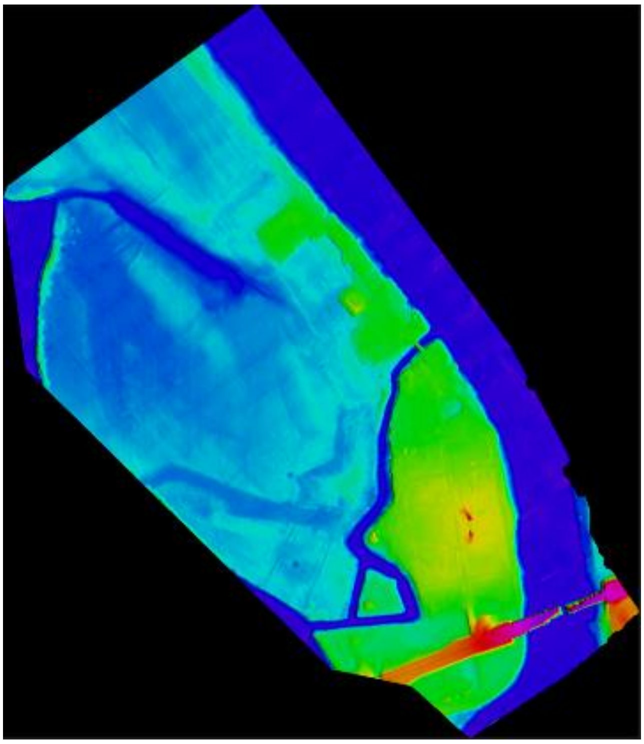

Fig. 1. Surface relief model of 9 March 2018. *(Source: prepared by the author)*

Data for second relief model were obtained from measurements performed on 1 May 2018 (see Fig. 2).

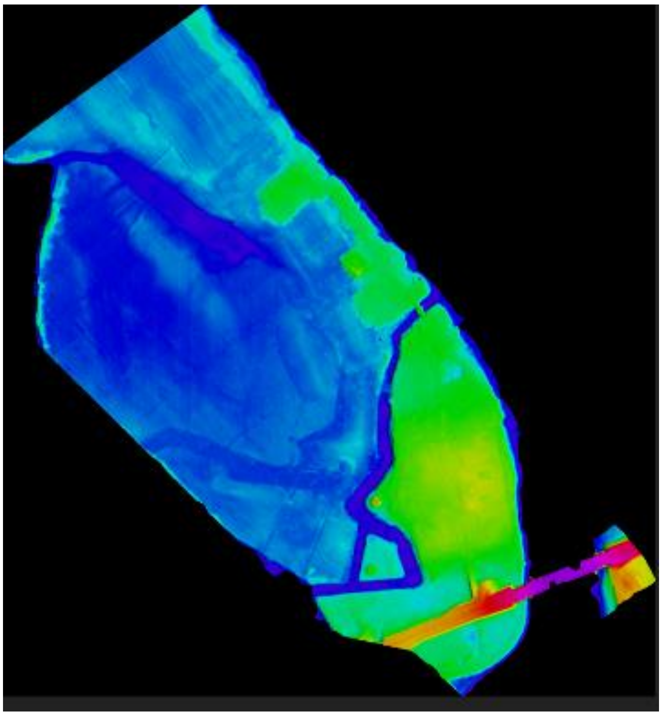

Fig. 2. Surface relief model of 1 May 2018. *(Source: prepared by the author)*

Discussions and results

As it was said before, two surface relief models were prepared in the framework of the research. They are different, because data are obtained in different time; data of the first relief model were obtained, when, ground was covered by snow and water was covered by ice, but data of the second relief model were obtained, when vegetation has started to bud or has finished budding practically.

On 9 March 2018, air temperature was plus 4 degrees. Deapth of snow in object of scientific research was 15 – 20 cm. Wind speed 3 – 5 m/s. Water bodies were covered by ice (Weather forecast, 2018).
On 1 May 2018, air temperature was plus 20 degrees. Sunny day, without clouds. Wind speed 10 – 15 m/s (Weather forecast, 2018).
In order to perform laser scanning for the southern part of the Castle Island in area of 58 ha, mission or plan of flight of unmanned aircraft was prepared. Totally three flights were planned and carried out, in order to prepare one relief model. So, 6 flights in total for both relief models. Both relief models had equal flight plans.
In the result of laser scanning, point cloud is obtained, which in the course of processing is created into point cloud model and georeferenced. Point cloud consists of millions points, each point contains information on coordinates of its location and intensity of the reflected signal (Catalucci et al., 2018).
Processing of point cloud and preparation of surface relief model was realized in Bently MicroStation with add-in of TerraSolid programm package.
In surface relief model of 9 March 2018 we can see that model is in the whole boundary of the object. This means that laser scanner has scanned surface of the Earth in whole boundary. Also in place, where is river Lielupe, the reflection is received, because river then was covered by ice. This concerns all water bodies within the boundaries of the object. Accuracy of measurements can be influenced by the snow existing in the object. Mutual flight trajectory shift after their alignment can be seen in Table 1.
Mean magnitude after data processing of laser scanning performed by 9 March 2018 was 0.1094 m. The largest magnitude was observed for trajectory 9 – 0.1856 m, but the least for trajectory 3 0.0695 m. The largest difference of heights was for trajektory 8 -0.1202 m. After the alignment of trajectories, it is necessary to perform alignment of points to performed control measurements, thus elevation differences are precluded and aligned.

Table 1

Trajectories of flight of 9 March 2018 after alignment

Trajectory	Point	Magnitude	Height, m
3	163721	0.0695	-0.0004
4	62139	0.0801	-0.0133
5	223799	0.1171	+0.0300
6	192260	0.1319	-0.0140
7	188104	0.1702	+0.1237
8	183728	0.1799	-0.1202
9	18444	0.1856	+0.0052
12	67124	0.0785	+0.0568
13	300121	0.0915	+0.0273
14	283102	0.0977	-0.0295
15	225977	0.0824	+0.0467
16	199588	0.1003	-0.0525
17	171652	0.0724	-0.0203
18	120055	0.1179	+0.0558
19	98940	0.1124	+0.0147
20	111366	0.0772	+0.0166
21	18144	0.0703	+0.0107
25	113961	0.1523	-0.0572
27	102555	0.1068	-0.0241
29	103772	0.0934	-0.0335

In surface relief model of 1 May 2018 we can see that model is not in the whole boundary of the object. This means that laser scanner unfortunately could not to scan surface of Earth in the whole boundary. Reflection is not received from the large water bodies, therefore there are empty places in the model. The Channel at the Jelgava Castle situated in the object is filled-in, because software has performed mutual triangulation of points. Mutual shift of flight trajectories after alignment can be see in Table 2.

According to processed data of 1 May 2018 we can see that trajectory 25 0.1012 m has the greatest magnitude, but trajectory 12 0.0590 m has the least one. Differences of heights for all trajectories is below 0.02 m. The mean magnitude was 0.0756 m.

When we compare data obtained in laser scanning, we can conclude, that the second flight (on 1 May 2018) was more successful and also more accurate, which facilitates further activities for preparation of the model.

Table 2

Trajectories of flight of 1 May 2018 after alignment

Trajectory	Point	Magnitude	Height, m
3	15385	0.0692	+0.0170
4	4992	0.0667	+0.0028
5	12121	0.0783	-0.0130
6	13631	0.0850	-0.0110
7	12371	0.0825	+0.0038
8	17663	0.0770	+0.0043
9	19080	0.0740	-0.0063
10	15161	0.0773	-0.0164
11	16840	0.0659	-0.0023
12	21132	0.0590	+0.0046
13	16998	0.0701	-0.0142
14	20639	0.0633	-0.0076
15	15895	0.0620	+0.0018
16	17159	0.0631	+0.0127
17	14564	0.0698	+0.0129
18	9505	0.0962	-0.0025
19	8084	0.0979	+0.0102
20	9175	0.1007	-0.0101
21	3241	0.0783	+0.0052
25	9499	0.1012	+0.0029
27	8630	0.0911	+0.0111
29	103772	0.0934	-0.0335

Additionally to preparation of surface relief models, also photo fixation by unmanned aircraft, to which camera is connected, was performed. After obtaining of photoimages, the images were processed by software Pix4D, and photo visualization plan as visual viewing material was produced (see Fig. 3).

When both surface relief models were compared, it was clarified that heights in the both models differ. There can be several explanations. Firstly, different weather conditions, in which laser scanning was performed. Rather many things are influenced by the wind speed during flight. The stronger is wind, the more difficult for unmanned aircraft is to maintain its route. Similarly, snow existing in March influences the result, because laser rays cannot break through snow and direct reflection from the surface of the Earth is not received.

Fig. 3. Photo visualization. *(Source: prepared by the author)*

End products obtained as a result of laser scanning data processing have broad usage, e.g., topography mapping, mapping and visualization of built-up areas, territorial planning, environment and nature management, monitoring included, monitoring of mining sites, information for planning of construction works, geology, hydrology and pedology, as well as other sectors, where geospatial information is necessary.

Conclusions and proposals

1. Remote sensing is complicated and complex science sector, nevertheless it gives versatile knowledge about geodesy, photogrammetry a.o. related sectors.
2. Laser scanning gives multiform possibilities for improvement of contemporary land surveying sector, as well as for facilitating human work, by allowing work be done faster and more securely.
3. Preparation of surface relief model is a time-consuming process that includes flight planning and preparation of end-product.
4. There are several factors that can influence the end result, for example, weather – snow or wind speed, also magnetic fields, therefore it is necessary to take all them into account and avoid as much as possible from impact of these factors by performing planning part correctly.
5. From data processing of laser scanning performed on 9 March 2018 we can draw conclusion that the accuracy of data obtained is not in the highest level, because the mean value of magnitudes is 0.1094 m. It may be for the reason of weather, e.g., wind speed.
6. From data processing of laser scanning performed on 1 May 2018 we can draw conclusion that data are more accurate than data obtained from the first laser scanning, the mean value of magnitude is 0.0756 m.
7. End products obtained in laser scanning data processing have very wide usage in many sectors related to geodesy and constructions.

Acknowledgements

The research was supported by the project "Strengthening Research Capacity in the Latvia University of Agriculture" (agreement No 3.2.-10/46; Z6).

Authors are thankful to GeoLux Ltd. company for technical support.

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